U.S. DEPARTMENT OF ENERGY | Nuclear Energy

Perspectives on the Office of Nuclear Reactor Technologies

NRT R&D Summit
March 20, 2012

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President Obama's Commitment to Clean Energy

"This country needs an all-out, all-of-the-above strategy that develops every available source of American energy."

President Barack Obama
State of the Union Address
January 24, 2012

- **Keep current reactors operating by extending plant life beyond 60 years with improved performance and safety (Roadmap Objective 1)**
- **Develop new nuclear energy technology to bring nuclear electricity to marketplace (Roadmap Objective 2)**
- **Look for other non-electric opportunities to allow penetration of nuclear energy into industrial and transportation markets (Roadmap Objective 2)**

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Meeting Administration's 2035 80% Clean Energy Standard

Source	Elect (TWhr)	CO_2 (Gton)	Elect (TWhr)	CO_2 (Gton)	Elect (TWhr)	CO_2 (Gton)
Coal	1800	1.85	2100	2.1	400	0.4
Coal (CCS)	0	0	0	0	200	0.02
Natural Gas	785	0.4	1030	0.5	1200	0.5
Nuclear (Large)	800	0	870	0	1000	0
Nuclear (SMR)	0	0	0	0	1000	0
Hydro	250	0	250	0	250	0
Renewable	130	0	320	0	650	0
Petroleum	40	0.04	0	0	0	0
TOTAL	**3800**	**2.3**	**4570**	**2.9**	**4600**	**0.92**

Replace Coal

A lot ~130 GW
Fast ~ 10 GW/yr

LWR, LEU

2010 U.S Electricity Consumption and CO_2 Emissions. *EIA*, *Fce = 0.42*

EIA Reference Projections 2035 Fce=0.43

Assumed 2035 electricity production to meet "clean energy" standard, *Fce = 0.8*

Assume: • Weighted Emission Standards: $F_{CE} = 1 - \left[\sum_i \varphi_i E_i / \sum_i E_i\right]$ • **Renewable and CCS goals met**

Φ = Coal= 1, Gas = 0.5, CCS =0.1

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NE 2012 Priorities

NE Top 3 Priorities

- Small Modular Reactor (SMR) Deployment
- Enhanced Accident Tolerant Light Water Reactor (LWR) Fuels
- Implementation of Blue Ribbon Commission Recommendations

Other NRT Top Priorities

- Energy Innovation Hub for Modeling and Simulation
- Light Water Reactor Sustainability R&D
- High Temperature Reactor Development for Process Heat Applications
- Development of the Advanced Stirling Radioisotope Generator in Support of NASA missions

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NE FY 2013 Congressional Request Funding Summary

(Dollars in Thousands)	FY 2011 Current	FY 2012 Enacted	FY 2013 Request
Integrated University Program	0	5,000	0
SMR Licensing Technical Support	0	67,000	65,000
Reactor Concepts RD&D	164,706	114,871	73,674
Fuel Cycle R&D	182,428	186,260	175,438
Nuclear Energy Enabling Technologies	50,891	74,670	65,318
Radiological Facilities Management	51,715	69,510	51,000
International Nuclear Energy Cooperation	2,994	2,983	3,000
Idaho Facilities Management	183,604	154,097	152,000
Idaho Safeguards and Security [a]	88,752	93,350	95,000
Program Direction	86,279	91,000	90,015
Adjustments	-5,373 [b]		
Total, Nuclear Energy	**805,996**	**858,741** [c]	**770,445**

a) Requested within Nuclear Energy in FY 2013 (retains Defense function), appropriated within Other Defense Activities FY 2011 and FY 2012.
b) Includes +1,500,000 transfer from Department of State, -$552,000 use of prior year balances for reprogramming executed in FY 2011 for INL S&S, and -$6,321,000 rescission of prior year balances.
c) Reflects rescission of $3,272,000 associated with savings from the contractor pay freeze.

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Small Modular Reactor Licensing Technical Support

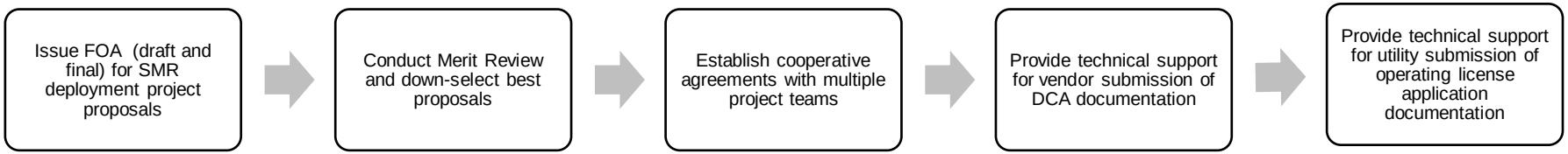
Budget Summary
$ in thousands

Program Element	FY 2012 Enacted	FY 2013 Request
SMR Licensing Technical Support	67,000	65,000
Total:	**67,000**	**65,000**

- **Mission**
  - Support design certification (DC) and licensing activities for 2 SMR designs through cost-shared arrangements with industry partners in order to promote deployment of SMRs that can provide safe, clean, affordable power options
- **FY 2013 Planned Accomplishments**
  - Complete negotiations on competitively selected cooperative agreements with SMR vendors and utility partners for cost-shared licensing activities
  - Complete milestones and commitments on design and licensing efforts supporting DC submittals to NRC
  - Continue to work with NRC and industry to address technical and regulatory issues that are vital to the licensing of SMR designs

Sequence

To accomplish its mission, the program will follow a defined path of action for the tasks that are within its scope.



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Reactor Concepts Research, Development, and Demonstration

Budget Summary
$ in thousands

Program Element	FY 2012 Enacted	FY 2013 Request
Small Modular Reactor Advanced Concepts R&D	28,001	18,479
Next Generation Nuclear Plant (NGNP)	40,000	21,557
Light Water Reactor Sustainability	25,000	21,661
Advanced Reactor Concepts	21,870	12,377
Total:	**114,871**	**73,674**

- **Mission**
  - Develop new and advanced reactor designs and technologies that advance the state of reactor technology to improve competitiveness and help advance nuclear power as a resource capable of meeting the Nation's energy, environmental, and national security needs
- **FY 2013 Planned Accomplishments**
  - Conduct R&D to support advanced SMR designs
  - Perform targeted fuels and materials R&D activities to support NGNP
  - Research technologies that support safe and economical long-term operation of the existing nuclear fleet
  - Conduct R&D on Advanced Reactor Concepts

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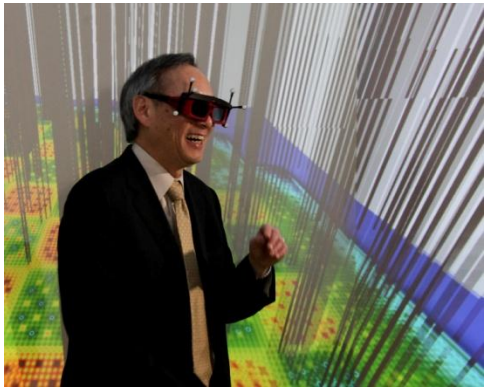
Nuclear Energy Enabling Technologies (NEET)

Budget Summary
$ in thousands

Program Element	FY 2012 Enacted	FY 2013 Request
Crosscutting Technology Development	35,899	26,167
Energy Innovation Hub for Modeling & Simulation	24,232	24,588
National Scientific User Facility	14,539	14,563
Total:	**74,670**	**65,318**



- **Mission**
  - Develop crosscutting technologies that directly support and complement NE's R&D efforts and encourage transformative and creative solutions
- **FY 2013 Planned Accomplishments**
  - Evaluate innovative materials for use in high radiation/high temperature areas
  - Develop advanced sensors and instrumentation to control and monitor plant performance while increasing safety and efficiency of operation
  - Deliver advanced modeling and simulation capabilities to be used in support of the reactor and fuel cycle R&D programs
  - Release the Virtual Reactor Code with significantly improved capabilities
  - Conduct materials and fuel experiments and post-experiment analysis at the unique facilities within the NSUF network

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Radiological Facilities Management

Budget Summary
$ in thousands

Program Element	FY 2012 Enacted	FY 2013 Request
Space and Defense Infrastructure	64,524	46,000
Research Reactor Infrastructure	4,986	5,000
Total:	**69,510**	**51,000**

- **Mission**
  - Maintain NE-managed nuclear facilities and capabilities at Idaho National Laboratory, Oak Ridge National Laboratory, Los Alamos National Laboratory and Sandia National Laboratories
- **FY 2013 Planned Accomplishments**
  - Ensure that DOE's nuclear capabilities supporting Space and Defense activities are maintained and operated in a safe, environmentally-compliant, and cost-effective manner
  - Provide universities with fresh fuel and shipment of used fuel to support continued operation of their research reactors

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Reflections on Past Year

- Fukushima
- New Nuclear Power Plants
- NRT Accomplishments
- Perspectives on Stakeholder Relationships

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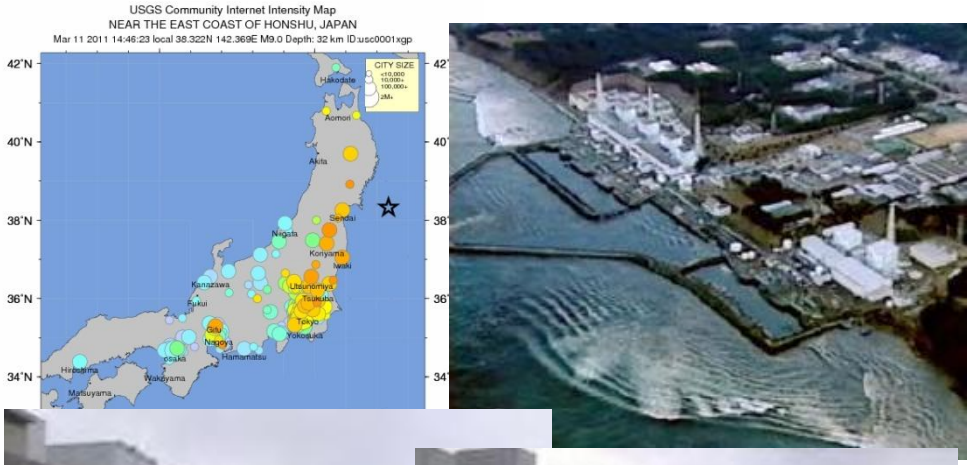
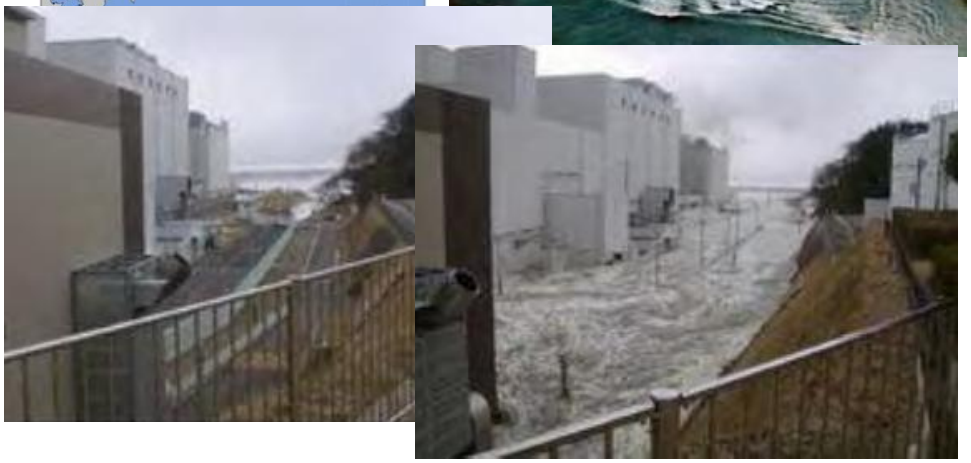
2011 Tōhoku Earthquake and Tsunami 3/11/11





- **14:36 JST Earthquake**
  - Magnitude: 9.0
- **Generated a 14m Tsunami**
  - 15:41 JST Tsunami
- **Many thousands perished**
- **More that 100 thousand people were homeless without food, water, or heat**

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Accident Sequence for Fukushima Dai-ichi Reactors

- Station blackout due to earthquake
- Loss of emergency diesels due to tsunami (nearly 1 hour later)
- Eventual loss of batteries and cooling to control steam driven emergency pumps
- Core overheats, cladding oxidizes and melts producing hydrogen
- Hydrogen escapes from containment and explodes/deflagrates in reactors 1, 2, & 3
- Explosion/deflagration in reactor 4 building

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Immediate Response of U.S. Government

U.S.NRC

- Activated its Emergency Operations Center
- Immediately deployed personnel to the U.S. Embassy in Japan to support the Reactor Safety Team
- Provided expert advice to U.S. Ambassador and Government of Japan ministers
- Set up and coordinated consortium call that involved NRC, INPO, DOE, and Naval Reactors

INPO

- Organized nuclear industry technical response to assist TEPCO

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- Activated its Emergency Operations Center focused on monitoring radiation release and impact on U.S. citizens (both in Japan & U.S.)
- Deployed Airborne Monitoring System aircraft and sensors
- Provided additional DOE Embassy reps to the two already assigned to the U.S. Embassy
- Deployed national laboratory reps from INL, PNNL and Sandia to provide technical assistance
- Stood up Science Council supported by NERT

- Provided equipment and capabilities to assist Japan

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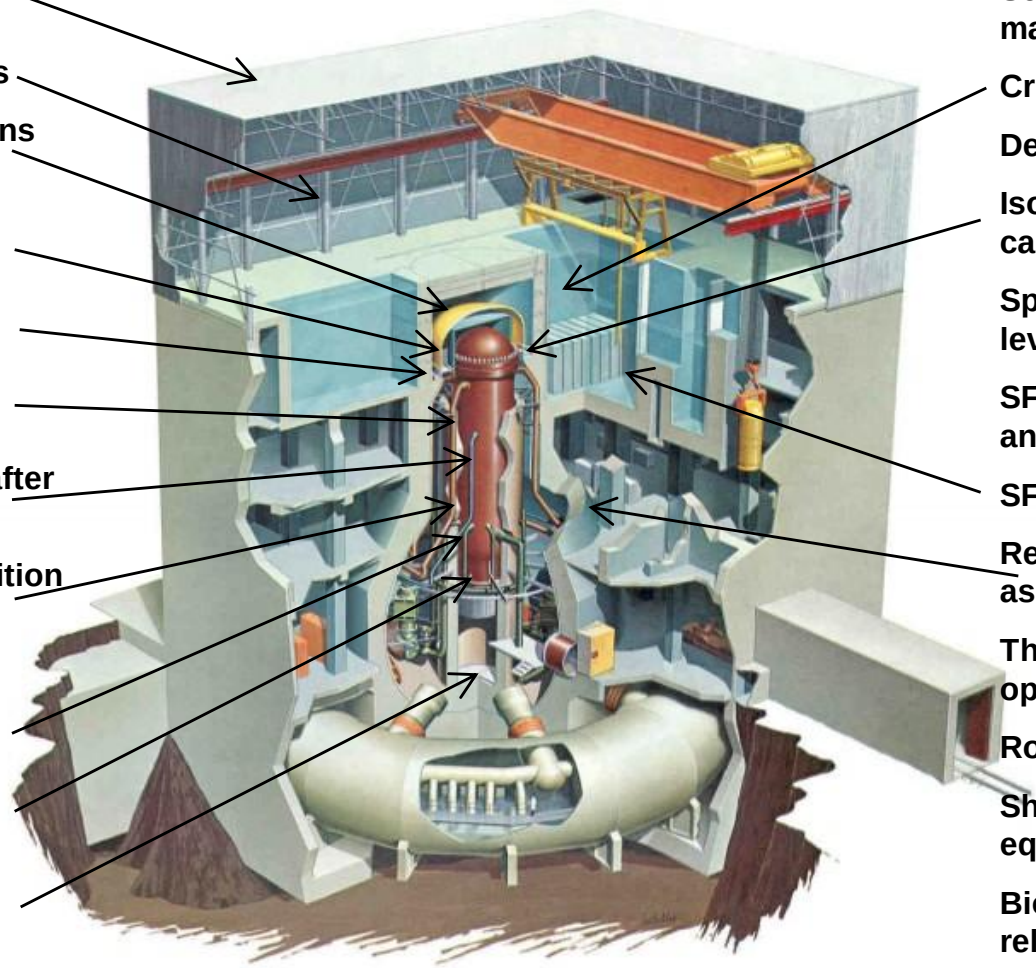
Snap Shot of DOE Analysis in the Weeks Following the Accident

- Collection of daily status data and events
- Isotopic analysis of releases
- H2 production and explosions in reactor buildings
- N2 inerting options and processes
- Gas inventory calculations
- Potential for further H2 production and explosions
- Structural analysis of RPV after pressure spikes
- Core damage and fuel condition
- Sensor data analysis
- Water level calculations
- Corrosion in sea water solutions
- Drywell filling options and water level tracking
- Stabilization criteria



- Severe accident analysis and management
- Criticality determinations
- Decay heat calculations
- Isotope and radionuclide calculations and releases
- Spent Fuel Pool (SFP) water level analysis
- SFP hydrogen production and analysis
- SFP modeling
- Reactor building and SFP dose assessments
- Thermal analysis for SFP fill options
- Robotics tools for stabilization
- Shielding advice for on-site equipment
- Bioaccumulation for water releases

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Fukushima Impacts on DOE/NE Research

- **Focusing efforts in many programs on safety and accident tolerance**
  - NEET, LWRS, NEAMS
- **Continuing programs to develop inherently safe advanced reactors**
  - NGNP, ARC
- **Forming new programs to look at advanced fuels and other technologies to improve accident tolerance**
- **Working with international community to analyze the accident to improve our modeling capability and develop lessons learned**

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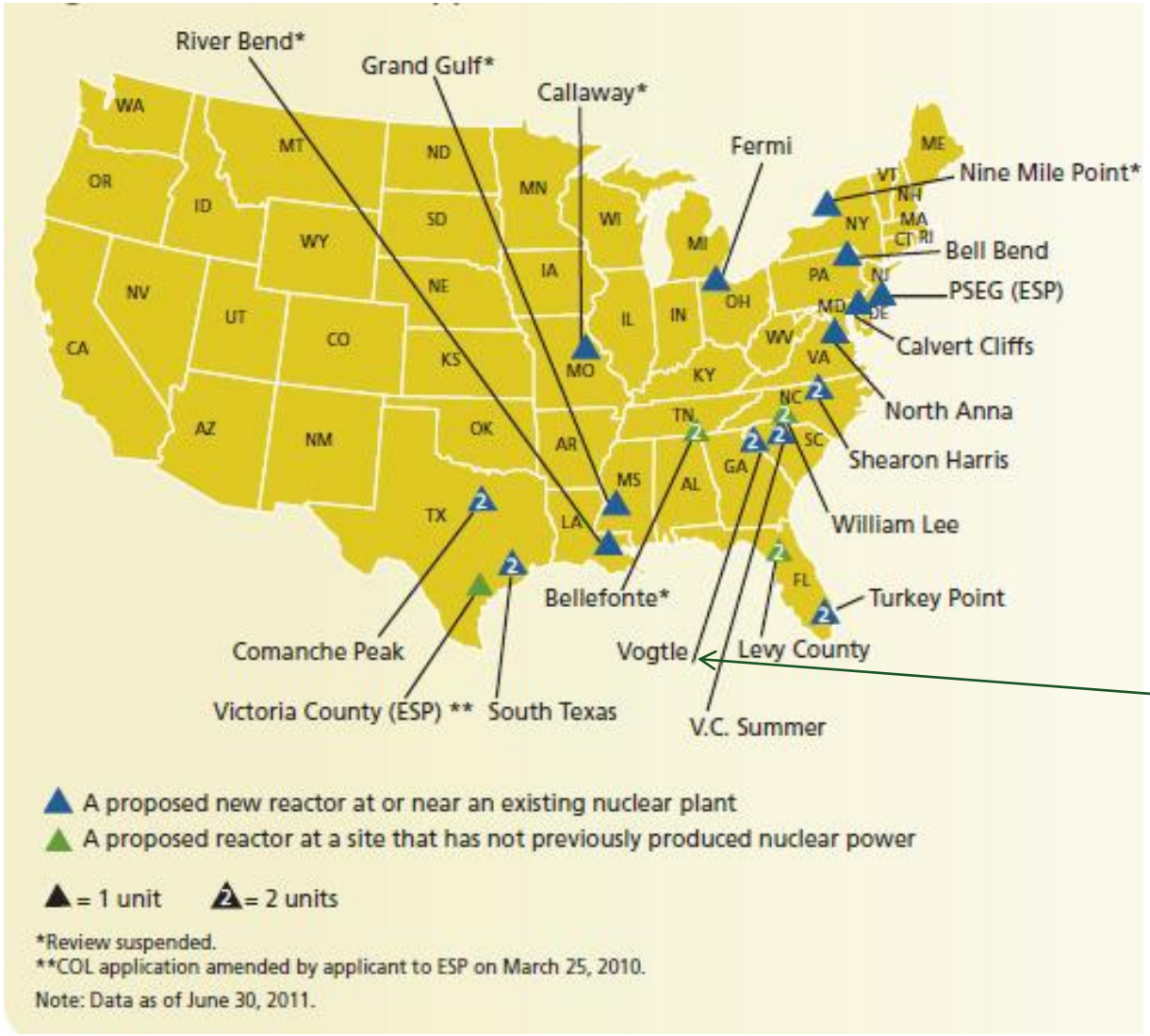
Continued Interest in Nuclear Energy – Proposed New Builds



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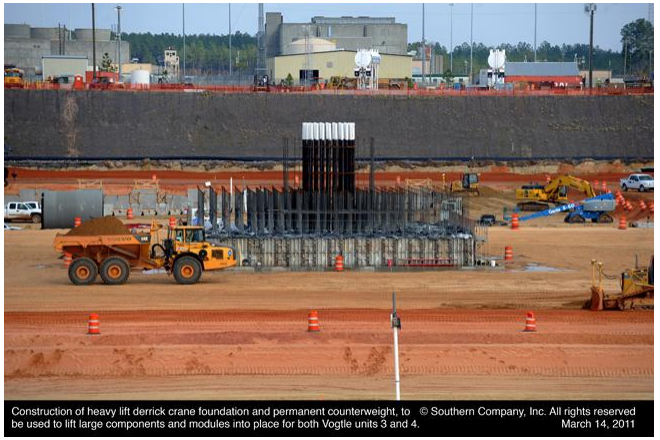
AP1000 Construction Sanmen and Vogtle



Construction of heavy lift derrick crane foundation and permanent counterweight, to be used to lift large components and modules into place for both Vogtle units 3 and 4.

March 14, 2011

Vogtle- March 2011

Sanmen- June 2011

Vogtle- Feb 2012

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Major NRT Accomplishments

- **Received authorization for SMR Licensing Technical Support and Advanced SMR R&D Programs**
  - Issued draft Funding Opportunity Announcement (FOA) for licensing technical support and plan to issue final by the end of March
- **Received authorization for the NEET Crosscutting Technologies Program**
  - Issued two FOAs for Reactor Materials and Advanced Methods for Manufacturing Research and Development
- **Completed ~357 out of 600 effective full power days for second NGNP fuel experiment (AGR-2)**
- **Issued a Request for Information to solicit information to inform reactor technology research portfolio (Technical Review Panel (TRP))**
- **Released initial versions of the Consortium for Advanced Simulation of Light Water Reactors (CASL) team's flagship Virtual Environment for Reactor Applications code and released code tools to predict fuels and reactor performance as part of NEAMS**
- **Fabricated and conducted test irradiations of Silicone Carbide cladding samples**
- **Completed the delivery, spacecraft integration, and safe launch of the DOE produced Multi-Mission Radioisotope Thermoelectric Generator power supply on the Mars Science Laboratory mission**

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Perspective on University Relationships

- **University projects are a major part of the NRT portfolio**
- **Universities must be engaged to generate new ideas and develop the workforce of the future**
- **Program Directed Integrated Research Projects are important for exploring advanced concepts to determine viability**
- **Results of university R&D projects need to be integrated into our programs**
  - Most of the effort is on the review and selection of proposals

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Perspective on Industry Relationships

- **President's and NE Roadmap goals are largely achieved through industry actions**
  - Industry will actually deploy technology
- **DOE and industry need to be much more closely coordinated to achieve our goals**
  - TRP Process
  - SMR FOA Process
  - Joint Integrated Program Plan with EPRI
  - NGNP Public-Private Partnership
- **Stakeholder outreach needs to be increased**

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Perspective on International Relationships

- **DOE has long recognized the importance of international collaborations**
- **International organizations such as Generation IV International Forum leverage our investments**
  - Significant given current fiscal constraints
  - Still struggling to realize the benefits of collaborations
- **Growing recognition that U.S. sales to international markets are critical to the whole of nuclear power in the U.S.**
  - Domestic deployment is necessary, but insufficient
  - Through international sales, the US can truly influence the world and re-establish U.S. technical leadership

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Perspective on the Evolving Role of Federal Staff

- **Goals set for nuclear energy require a technically strong and objective government organization**
- **Role of federal staff is *not to tell the labs how to do the R&D*, but *to ask the right questions* thereby helping the labs make even greater contributions to the country**
- **Promote a culture of critical thinking by challenging and questioning**
- **This is still a work in progress**

Questions?